Space Weather Technical Forecast

Issued on Tuesday, 24 January 2023 at 12:33 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Reducing risk of R1/R2 Radio Blackouts and G1/Minor Geomagnetic Storms after midweek (UTC).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with GOES16 recording C-class activity. These flares peaked with a C6.6 from AR3194 at 24/0426UTC, which was becoming increasingly difficult to analyse as it neared the southwestern limb, although perhaps presenting as a Dac/Beta with an apparent areal decaying trend.

AR3194 was one of eight numbered spot groups on the Earth-facing disc at present, with AR3191 becoming indistinct in the northwest and consequently dropped from the analysis. This was counteracted in part by the potential development of a new unnumbered northeastern quadrant bipolar region overnight UTC, while another unnumbered unipolar region rotated onto the northeast.

In terms of the numbered groups, AR3190 dominates in terms of size and nominal complexity, showing as a consolidating and growing Eki/Beta-Delta as it nears the limb, with the Mt Wilson delta becoming more distinct as a constituent part of the largest penumbral group. Changes in other spots on the disc were more subtle, with some movement of the spots comprising AR3199, 3196, 3194, and 3192, although for the most part these groups were well-spread in their composition and magnetically simple.

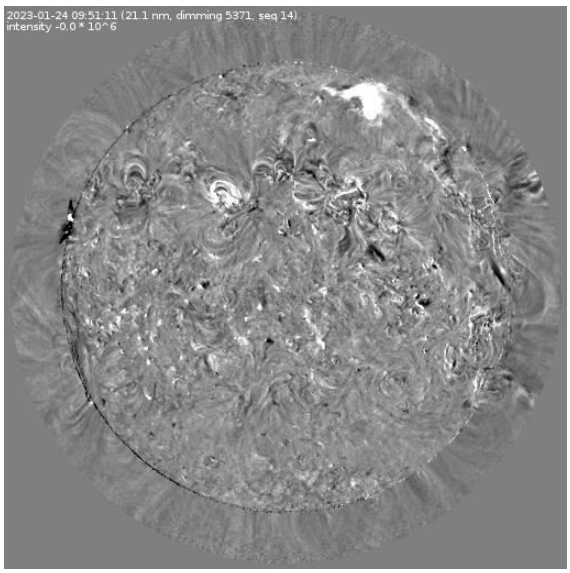

Figure 0: Time-integrated AIA211 imagery of the mobile filament near the northwestern limb around 24/0800-1000UTC. This feature has not yet been confirmed as having left the immediate solar environment, with imagery awaited. Image processing courtesy of SIDC ROB.

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There are currently numerous filaments on the solar disc, with most of these concentrated near the western solar limb in both hemispheres, which is of note as they could be triggered by the more active sunspots here should they flare appropriately. This appears to have resulted in activity into the UTC morning of the current day, with a large filament becoming mobile between 24/0800-1000UTC in the northwest. It is not yet clear whether this movement has translated into an ICME, however coronagraph imagery will be monitored. Imagery otherwise showed one northwest-directed and likely far-sided emission from 24/0600UTC.

Finally a Type-II radio emission with an associated estimated speed of 324km/s was reported at 24/0324UTC. The source may have been a minor C2.5 from AR3198, near centre-disc, although the nearest ejecta appears to be heading northeast from limited imagery on Lasco C2. No new Earth-directed CMEs were therefore in evidence at the time of writing, however this final event remains to be analysed.

Solar Wind / Geomagnetic Activity: Solar winds, as measured at L1 by ACE and DSCOVR, were suggestive of the tail end of influence from a CME. The shock from this feature had been diagnosed as having reached L1 around 23/0300UTC, with this subsequently evolving into a magnetic cloud-like signature from the very start of the current reporting period, i.e. 23/1200UTC, with the IMF showing discontinuities at both points. The CME responsible is not certain, but is most likely to be the 19 January faint halo or the southwest quadrant filament from 20 January - or perhaps a combination of both given the faster speed of the latter and the potential for a 'cannibalistic' united front.

The solar wind speed was again erratic (as measured) but perhaps best described as an overall decreasing trend from Elevated to Slightly Elevated levels. The solar wind density was slightly above average in low double figures, but again with a slight fall observed with time. The IMF was greatest early in the 24 hours and showed a smooth decaying envelope from 8nT to nearer 5 by the period's end. The north-south component of the magnetic field was mainly anti-aligned with Earth's to end the UTC day of Monday 23 January, but generally followed a smooth sinusoid into co-aligned territory into the current UTC day, eventually becoming more erratic as the CME magnetic cloud gave way to a more nominal regime. The phi angle was mainly positive (away from the Sun) throughout this period, with occasional brief dalliances in a negative sector.

The net effect of the above solar wind measures was Quiet to Unsettled geomagnetic activity, with a provisional peak Kp of '3o' in the 12-15UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 has been at Background levels throughout.

High energy electron flux (greater than 2 MeV) has been at Normal Background to Moderate levels. The 24-hour integrated electron fluence stayed well below the Active threshold on a roughly level trend, with 9.3e6 integrated pfu observed at 24/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is carries a daily Chance of becoming Moderate, with the most potent regions in the southwest. These should rotate off the disc after midweek UTC to slightly reduce the daily chances of M-class activity.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast is of lower than average confidence for the period. The likelihood of any outstanding CMEs now affecting Earth is much-reduced, and any remaining in transit should have passed 1AU by midweek.

The forecast therefore mainly comprises up to two fast wind streams, firstly from CH69/+ which was due today but appears to be slower than anticipated. There is now considered a Slight

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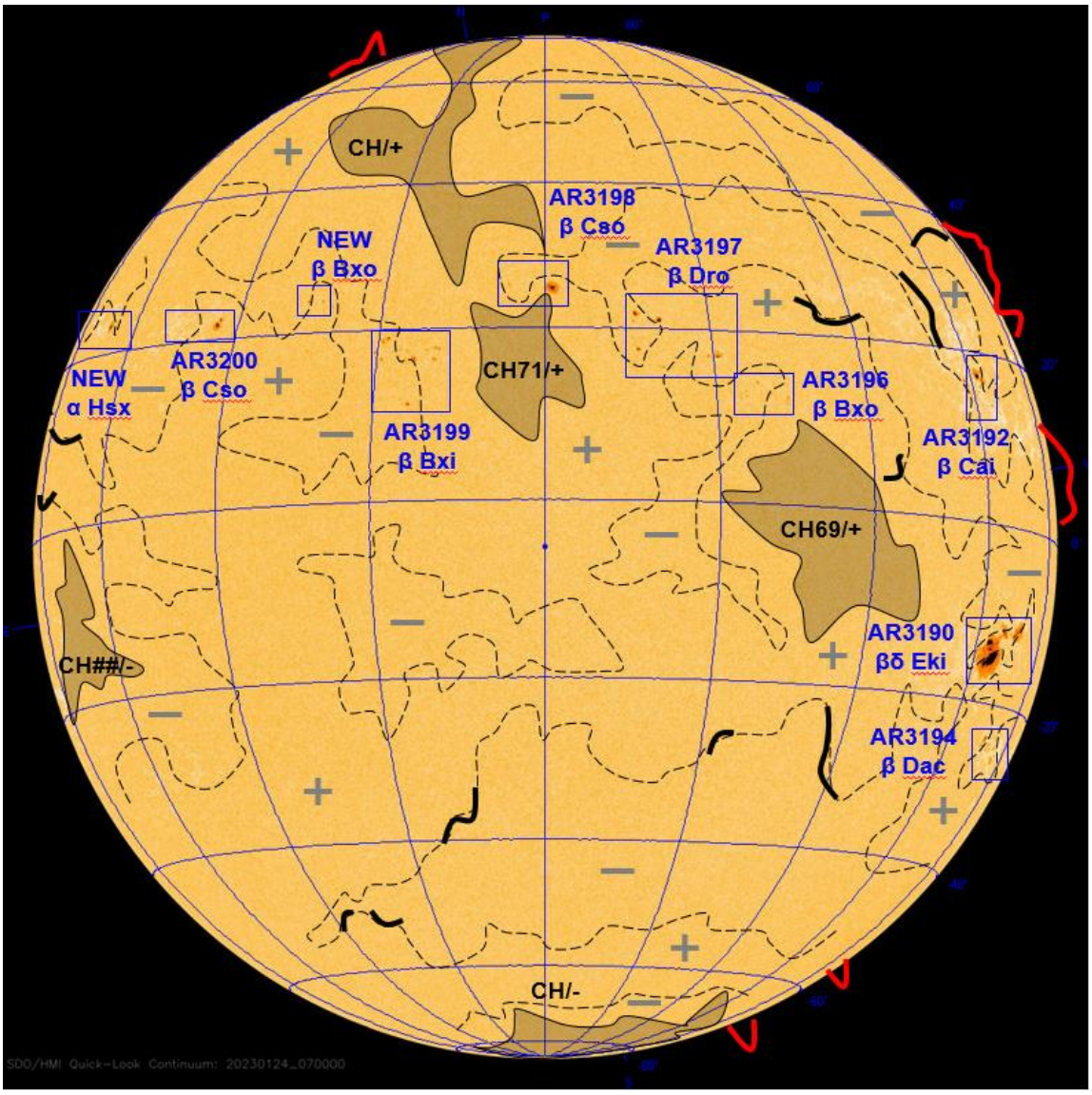
Chance of G1 on Wednesday 25 January, easing later this week to potentially be succeeded by a similar risk of G1 before the UTC weekend in the fast wind of CH71/+.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is likely to remain at predominantly Background levels, but with a Slight Chance of reaching S1 or greater through the period. This risk should begin to abate into the coming UTC weekend.

Electron flux should remain at Normal Background to Moderate levels, as at present, although this carries low confidence due to a number of CMEs and a non-persistent coronal hole fast wind due in the period. The greatest likelihood of surpassing Active fluence should arrive after midweek UTC and the expected fast wind, with the effect on electrons rated as an eventual Chance of Active fluence at peak.

Figure 1. Solar Analysis Valid 24/0700UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The geomagnetic forecast is of lower than average confidence for the period.

The last 36 hours of solar wind measurement are indicative of a passing CME, although the culprit is uncertain given up to three that were thought to be in transit. Should the 19 January or 20 January filament CMEs not form part of this CME signature, they are now not likely to affect Earth for being overdue. Although not conclusive, there is no obvious current signal in ACE EPAM LEMS to indicate anything CME-related is imminent, and these earlier two CMEs are therefore dropped from further consideration.

This leaves a flare-generated CME that was largely angled south of the ecliptic plane on 20 January as the only potentially outstanding feature - this too should have passed 1AU by the end of the current UTC day.

The above considerations should soon leave a clean slate in terms of impending CMEs which means the forecast then comprises coronal hole fast winds exclusively.

Unfortunately, the expected features are respectively non-persistent in the case of CH69/+; and much-changed versus last pass in the case of CH71/+. The effects from both are expected to be relatively muted in any case, with both being positive polarity on our approach to the negative-favouring spring equinox. CH69/+ had been expected in the current UTC day, however the latest STEREO A MAG and PLASTIC measurements persist in their absence of any notable fast wind signature. This means any fast wind will be later and slower, and there is therefore now a Slight Chance of G1 on day two, Wednesday 25 January. A lull should follow this for a time before a second risk of G1 from CH71/+ into the UTC weekend. This feature is smaller and retrogressed on the disc relative to last rotation, meaning weaker and later arrival respectively.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
20/2222	Partial	Flare	SW	450km/s	24/1800UTC	Possible glancing blow, low confidence

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Figure 2: AIA211 imagery from the previous and current rotations showing the absence of an analogue for coronal hole 69 on last pass and the much-changed stature of CH71.

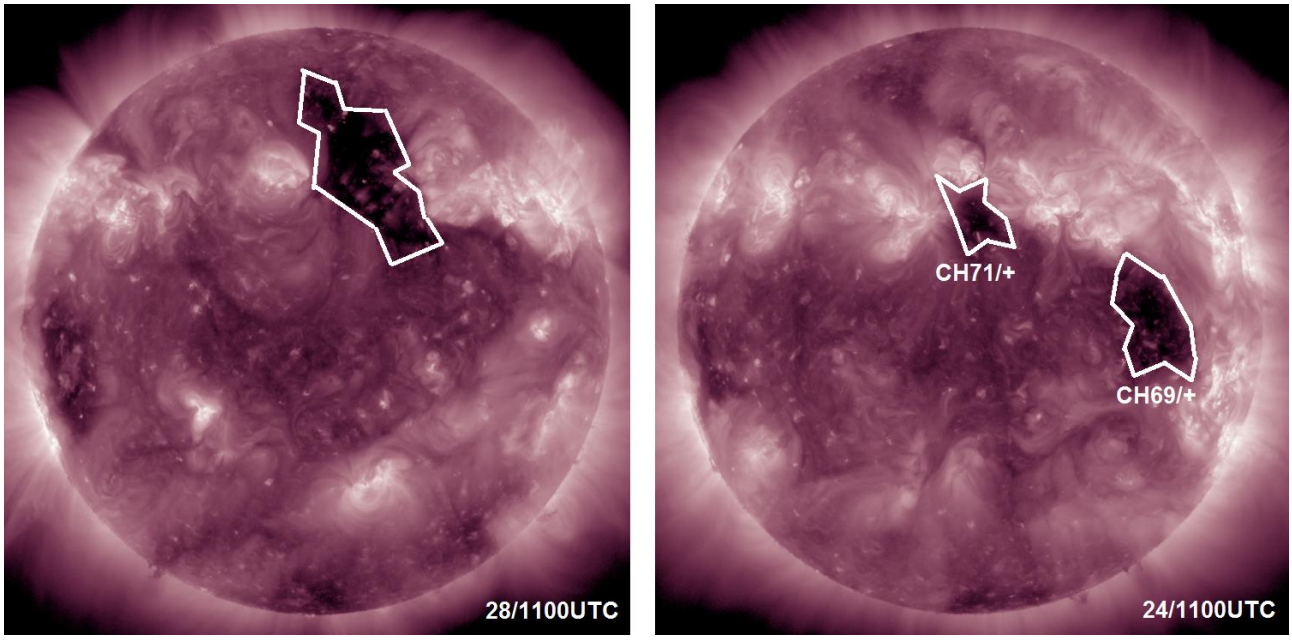
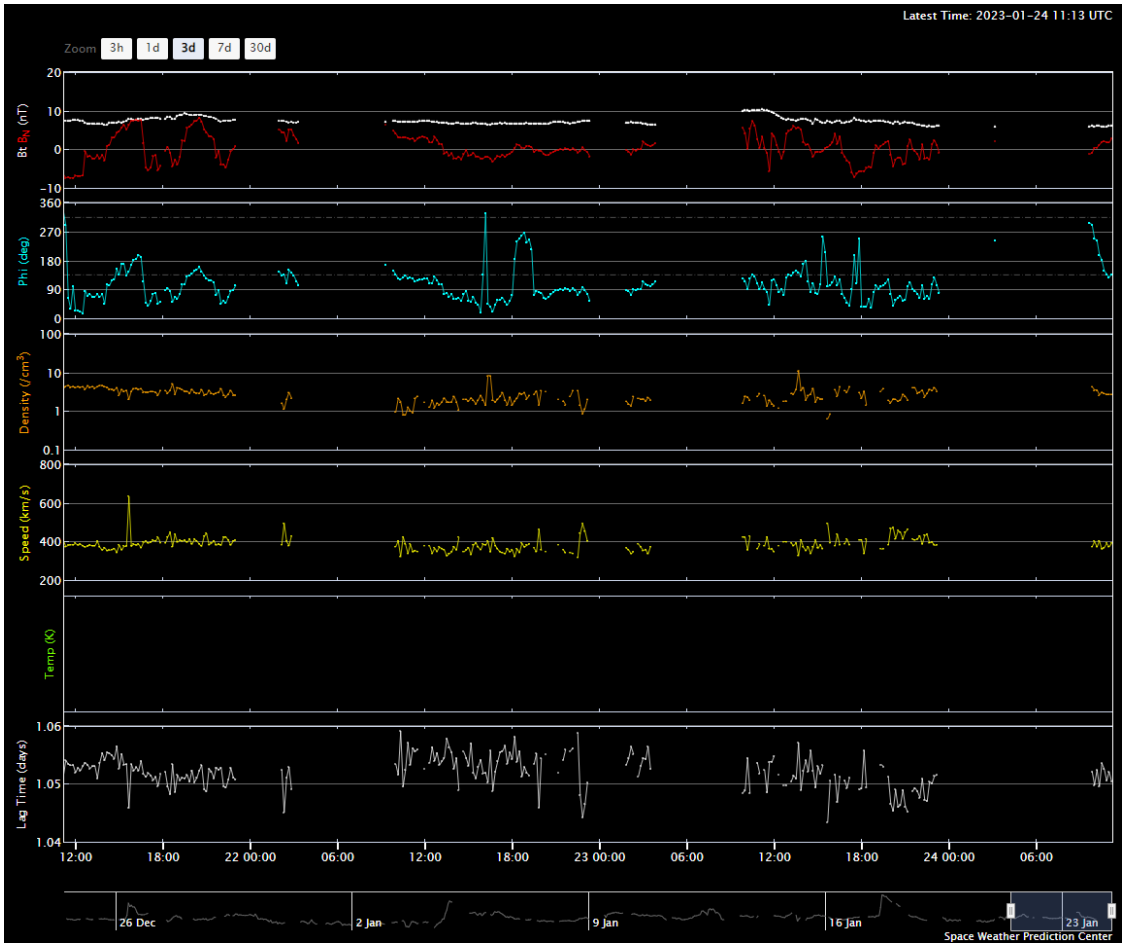


Figure 3: Past three days of STEREO A MAG and PLASTIC measurements, which despite a data gap suggest that there is no significant fast wind within a day from influencing Earth.


Latest Time: 2023-01-24 11:13 UTC
Zoom 3h 1d 3d 7d 30d
Bt, Bn (nT)
Phi (deg)
Density (/cm³)
Speed (km/s)
Temp (K)
Lag Time (days)
12:00 18:00 22 00:00 06:00 12:00 18:00 23 00:00 06:00 12:00 18:00 24 00:00 06:00
26 Dec 2 Jan 9 Jan 16 Jan 23 Jan
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Radio Blackouts - X-Ray Flares:

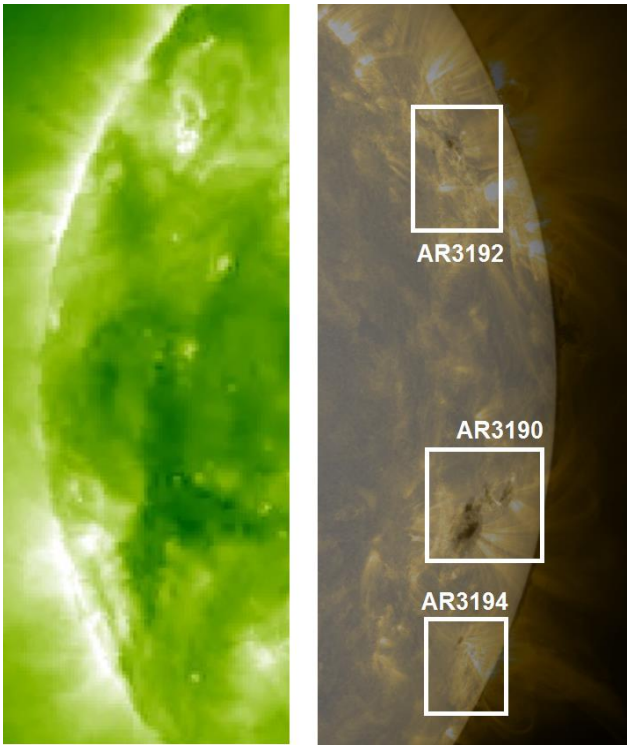
Solar activity has been Low in the past 24 hours.

While the disc remains well-populated in terms of sunspot region numbers, the relative complexity of the eastern solar hemisphere compared with the western limb is lower, and the departure of AR3190, AR3192 and AR3194 in turn after midweek should serve to reduce the overall daily risk of M-class flares.

Far-side soundings, returning Carrington locations of past spots and STEREO A EUVI195 imagery all hint that there may be a handful of arrivals over the eastern limb in the period, however aside from yesterday's far-sided halo CME from around 160E (its inferred emission position at that time), there is little evidence that any of these arriving sunspots will compensate for the departures, and the daily chances of significant flares therefore fall with time.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	50	50	40	40
Very Active	R3 to R5 X Class	No	5	5	1	1

Figure 4: (Left) 24/1000UTC STEREO A EUVI195 imagery showing around a day's worth of arriving bright flux regions containing potential spots; Right: HMIIF and AIA171 composite for 24/1000UTC showing the three main sunspot regions on the disc, all soon due to depart the Earth-facing side.



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at Background levels.

While there have been examples of slight enhancements to around 1pfu in the past ten days or so at GOES16, the current disc does not appear to be particularly prone to their generation, and the largest sunspots on the disc have shown a tendency towards maturity and a reduction in large flare activity.

All considered, there is a daily Slight Chance of S1 or above, with the chief contributors to this risk all now nearing the western solar horizon. This risk should begin to ebb away as these regions rotate away onto the far side into the coming UTC weekend.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

Electron flux should remain at Normal Background to Moderate levels, as per its current diurnal oscillation.

The chances of geomagnetic activity before midweek are now reduced, but the electron flux has not shown any willingness to rise beyond its current level even in this absence of activity, and the current observations probably represent a near-steady state.

The chances of Active 24-hour integrated electron fluence are now considered lower than in previous guidance, with the expected fast wind from CH69/+ now looking later and more muted than expected. Any electron response will probably arrive by the end of the current working week between the fast winds from CH69 and 71, however this is now judged as a low-end Chance, and even this ought to be brief should it occur.

MOSWOC REFM is not considered particularly useful guidance at present given the relative dominance of non-persistent features in the forecast, however it suggests levels below Active throughout the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	25	25
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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